US010451994B2

(12) **United States Patent**
Sobue

(10) **Patent No.: US 10,451,994 B2**
(45) **Date of Patent: Oct. 22, 2019**

(54) **IMAGE FORMING APPARATUS CAPABLE OF CORRECTING POSITION OF IMAGE FORMED ON IMAGE BEARING MEMBER**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **15/334,601**

(22) Filed: **Oct. 26, 2016**

(65) **Prior Publication Data**

US 2017/0123340 A1 May 4, 2017

(30) **Foreign Application Priority Data**

Oct. 28, 2015 (JP) 2015-211849

(51) **Int. Cl.**
G03G 15/043 (2006.01)
G03G 15/01 (2006.01)
G03G 15/00 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/043*** (2013.01); ***G03G 15/01*** (2013.01); ***G03G 15/011*** (2013.01); ***G03G 15/5058*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/50; G03G 15/5041; G03G 15/5054; G03G 2215/0158; G03G 2215/0161
USPC 399/40, 49, 72, 301
See application file for complete search history.

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2011/0280599 A1* 11/2011 Ino G03G 15/0189 399/44
2012/0275811 A1* 11/2012 Sasaki G03G 15/0194 399/72

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(57) **ABSTRACT**

An image forming apparatus that is capable of determining whether a measurement image is formed normally. First and second image forming units form first and second images on an image bearing member using first and second color toners. Reflectance of first toner is higher than the image bearing member and is higher than the second toner. A controller controls image forming units to form first and second measurement images superimposed. A correction unit corrects a positional relationship between the first and second images based on a position of the first measurement image detected based on an output timing of a signal indicating that the received light amount is not less than a threshold. A prohibition unit prohibits the correction unit from correcting the positional relationship when a period during which the signal is output is different from a predetermined period.

16 Claims, 11 Drawing Sheets

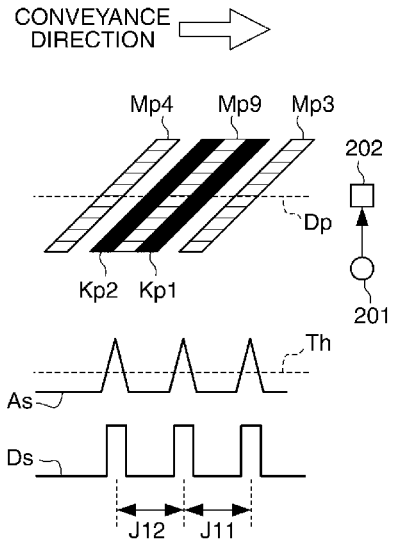

FIG. 1

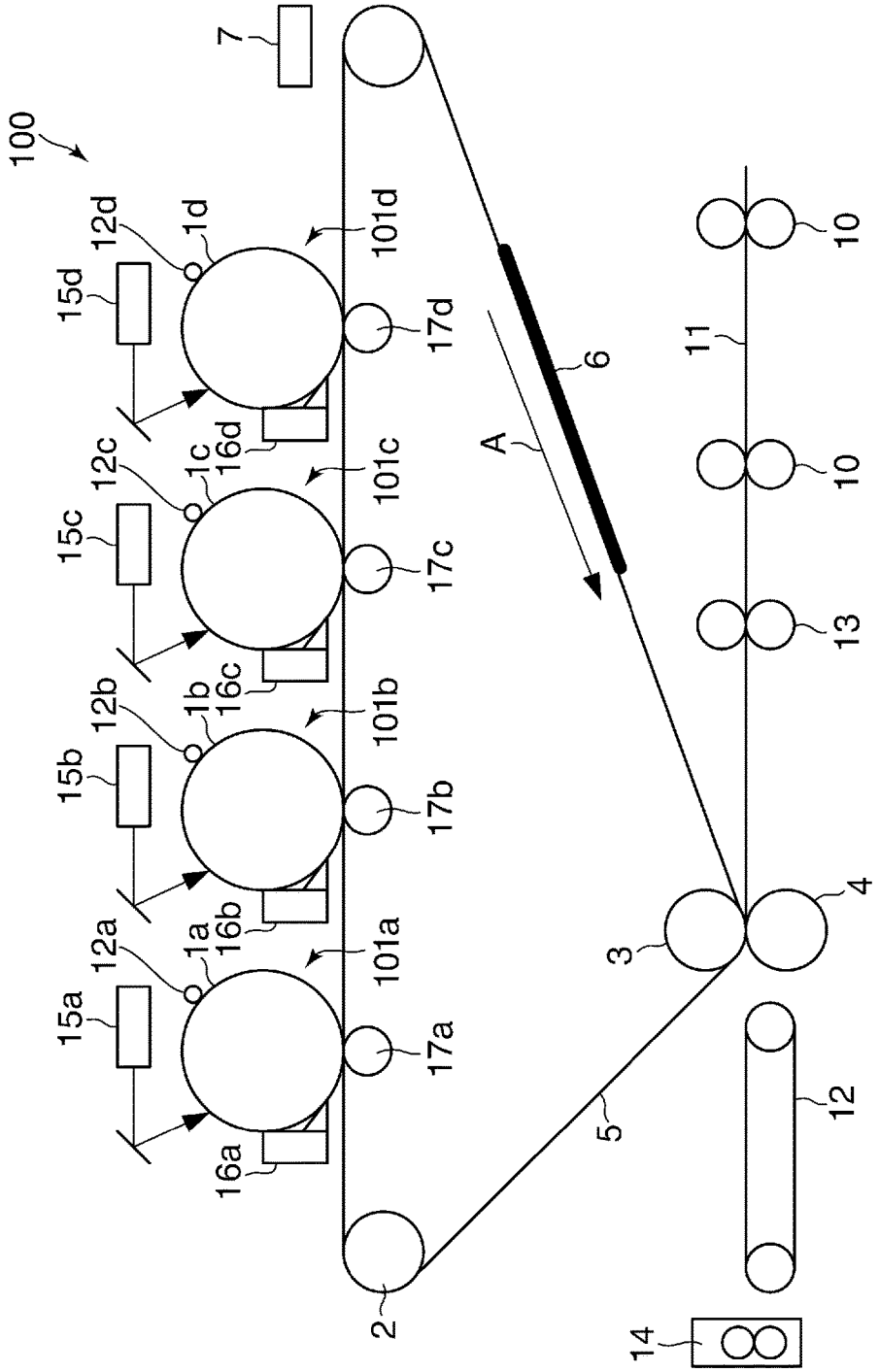
100
7
1d
12d
15d
16d
101d
17d
1c
12c
15c
16c
101c
17c
1b
12b
15b
16b
101b
17b
1a
12a
15a
16a
101a
17a
2
3
4
5
6
A
10
11
10
13
12
14

FIG. 2

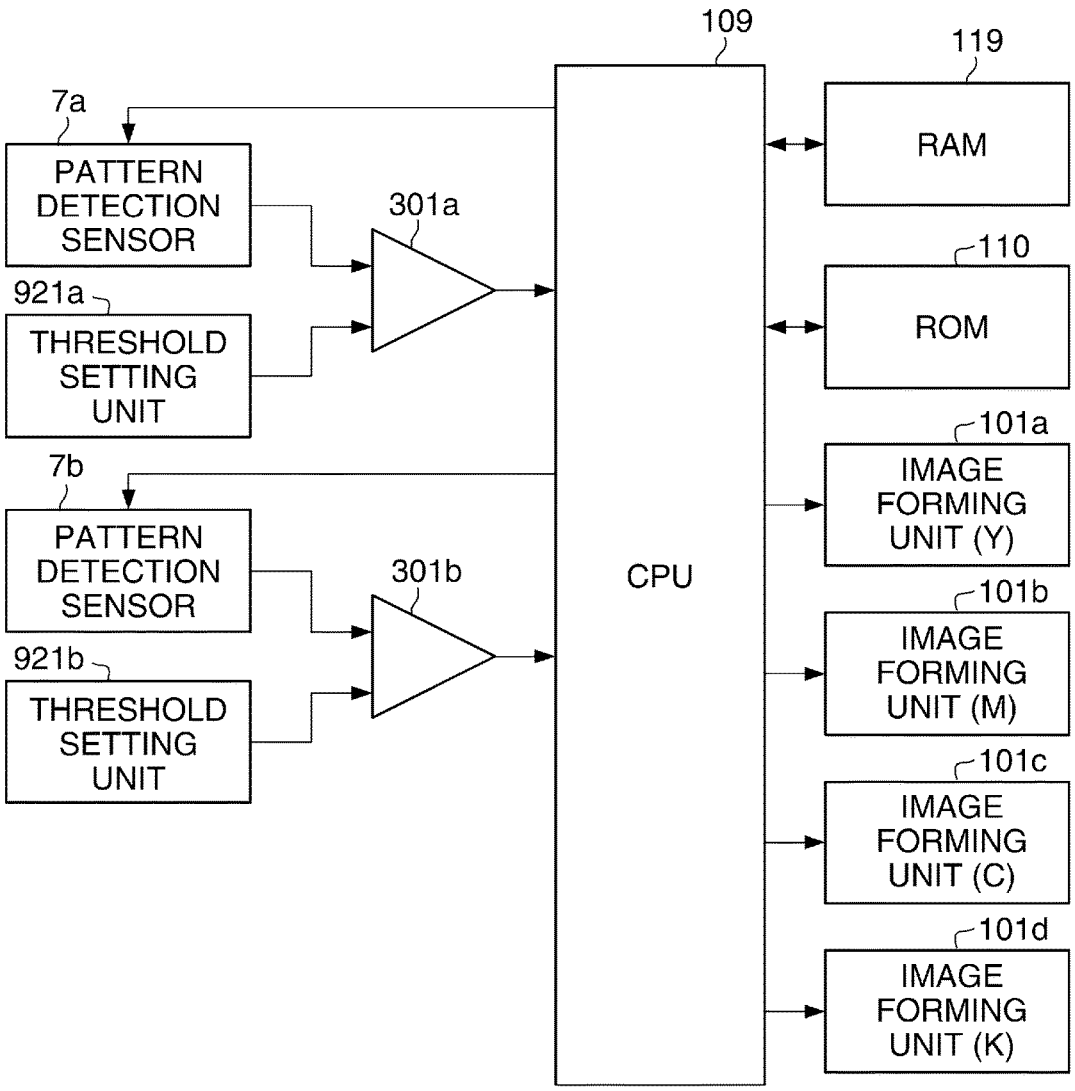
109
119
7a
PATTERN DETECTION SENSOR
301a
921a
THRESHOLD SETTING UNIT
RAM
110
ROM
101a
IMAGE FORMING UNIT (Y)
7b
PATTERN DETECTION SENSOR
301b
921b
THRESHOLD SETTING UNIT
CPU
101b
IMAGE FORMING UNIT (M)
101c
IMAGE FORMING UNIT (C)
101d
IMAGE FORMING UNIT (K)

FIG. 3

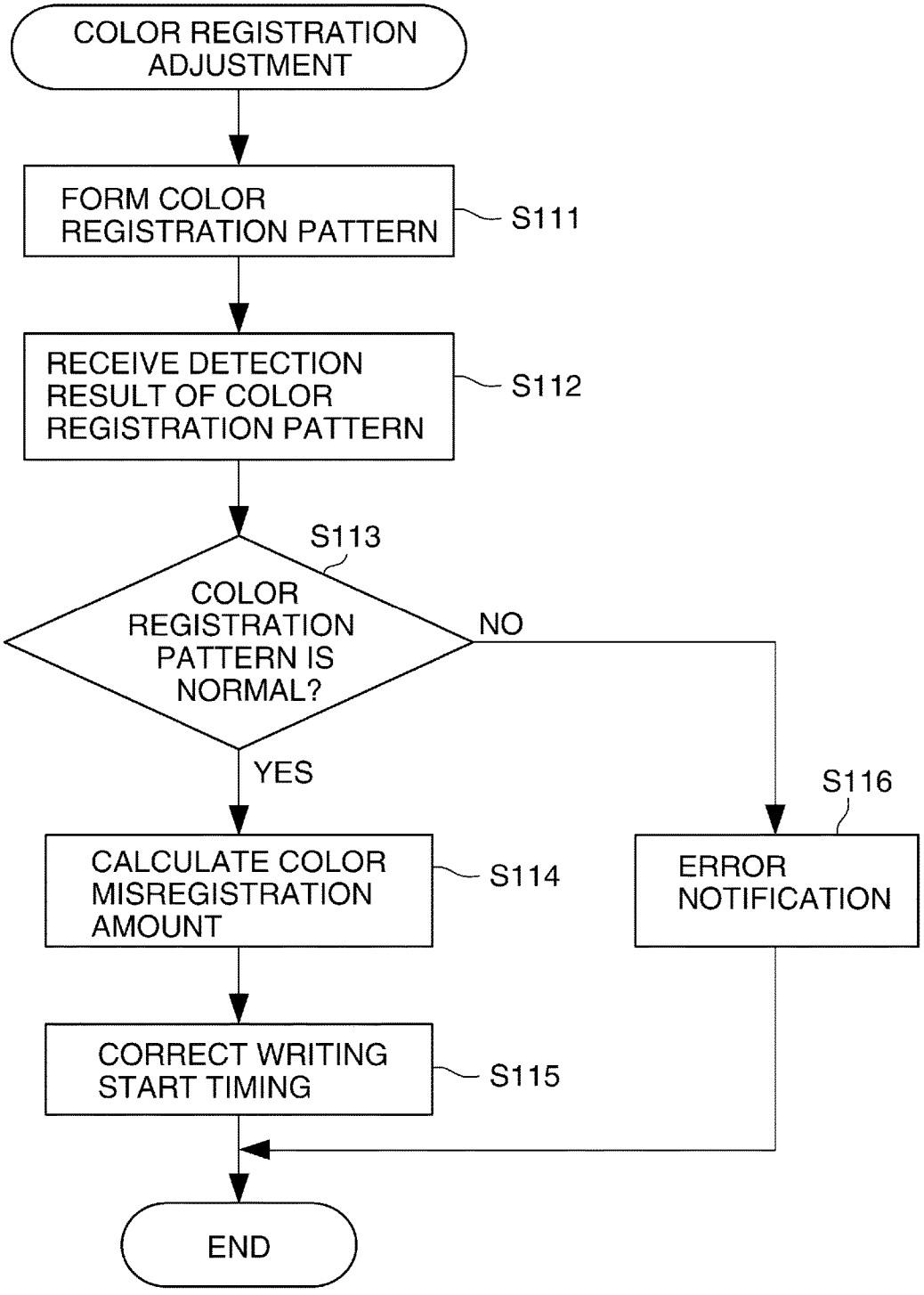
COLOR REGISTRATION ADJUSTMENT
FORM COLOR REGISTRATION PATTERN
S111
RECEIVE DETECTION RESULT OF COLOR REGISTRATION PATTERN
S112
S113
COLOR REGISTRATION PATTERN IS NORMAL?
NO
YES
S116
CALCULATE COLOR MISREGISTRATION AMOUNT
S114
ERROR NOTIFICATION
CORRECT WRITING START TIMING
S115
END

FIG. 4

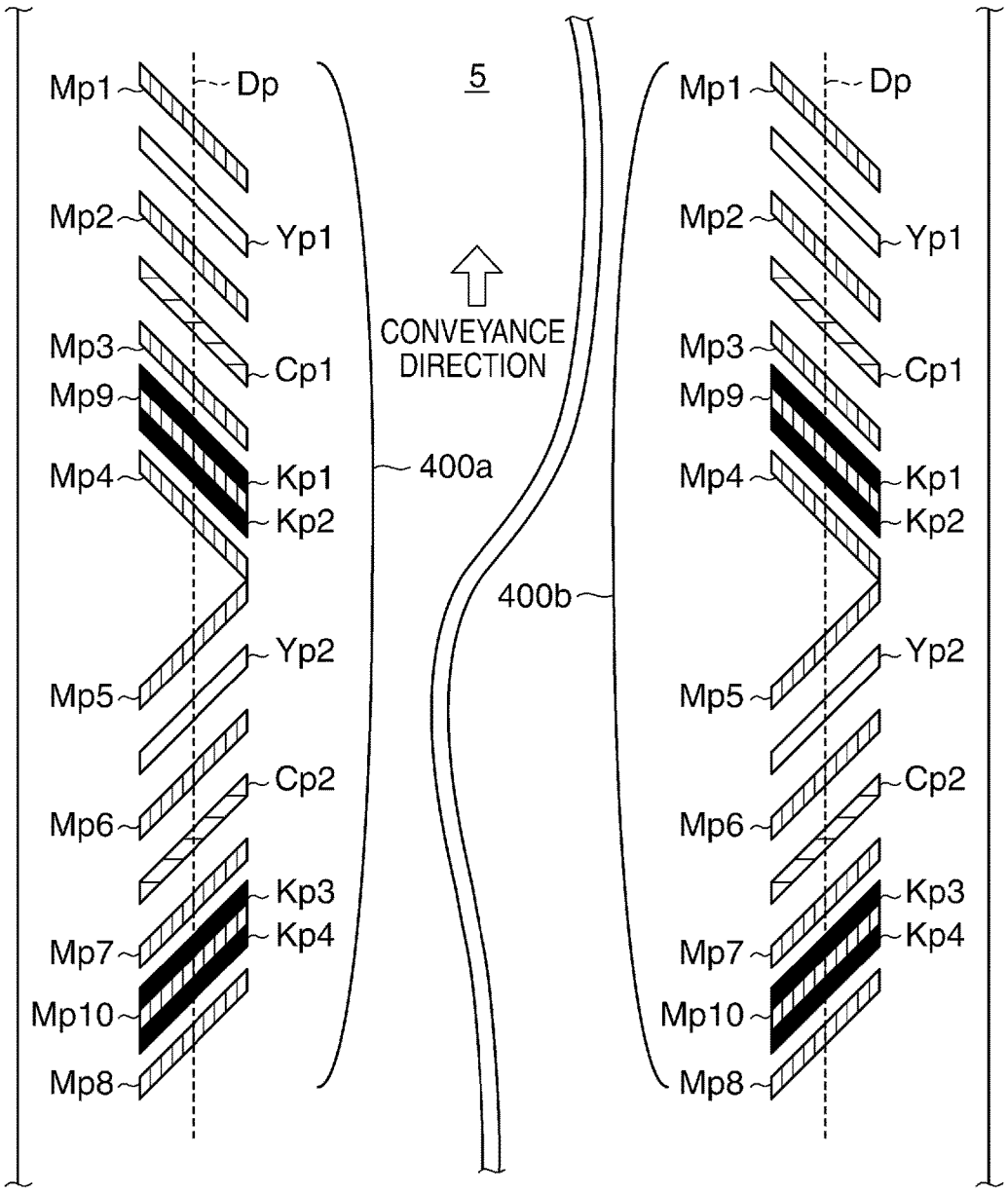
5
Mp1
Dp
Mp2
Yp1
Mp3
Cp1
Mp9
Mp4
Kp1
Kp2
Yp2
Mp5
Cp2
Mp6
Kp3
Kp4
Mp7
Mp10
Mp8
CONVEYANCE DIRECTION
400a
400b

FIG. 5

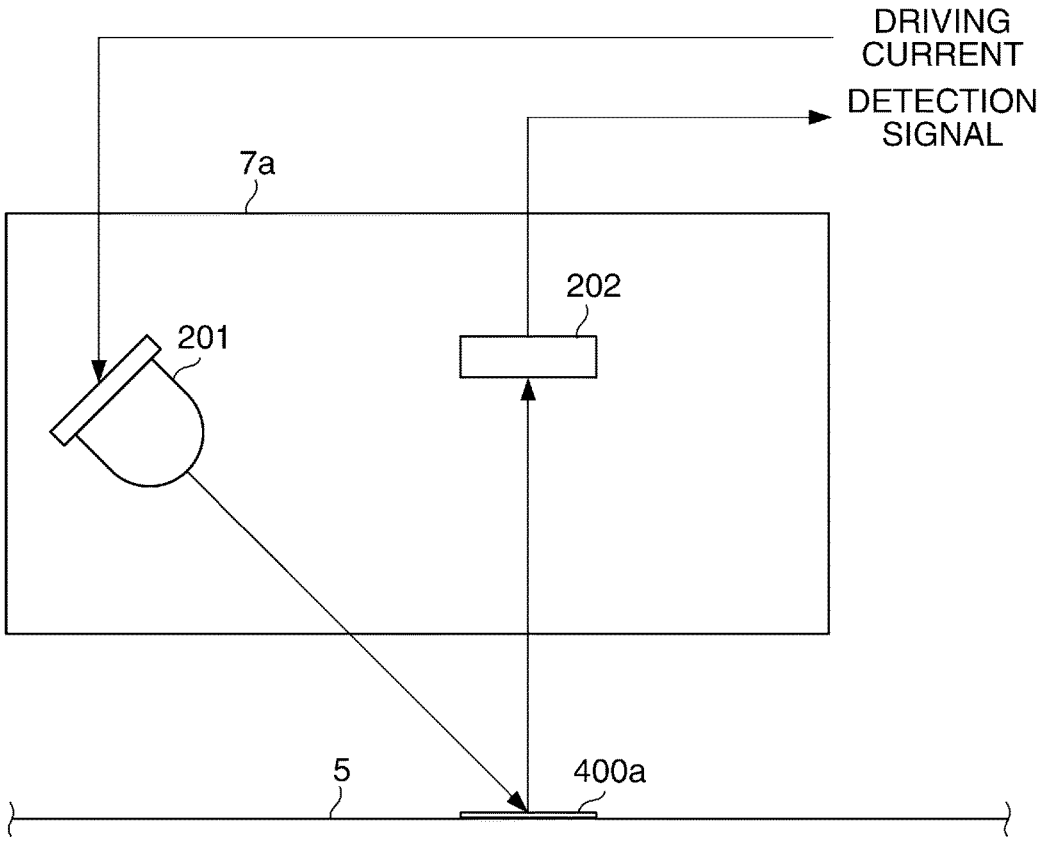

FIG. 6A

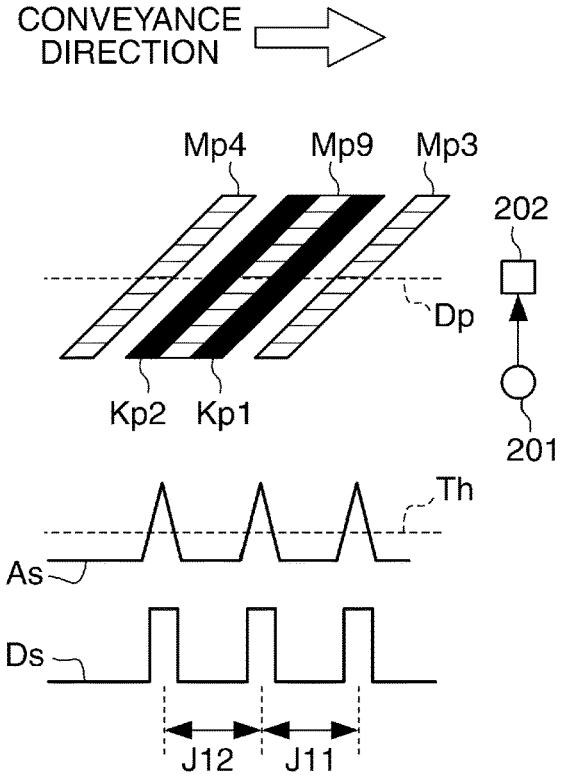
CONVEYANCE DIRECTION
Mp4
Mp9
Mp3
202
Dp
Kp2
Kp1
201
Th
As
Ds
J12
J11

FIG. 6B

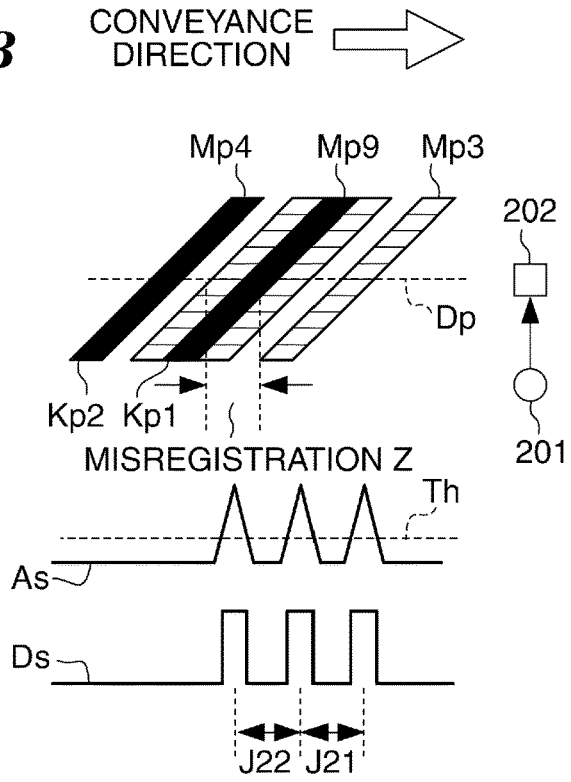
CONVEYANCE DIRECTION
Mp4
Mp9
Mp3
202
Dp
Kp2
Kp1
MISREGISTRATION Z
201
Th
As
Ds
J22
J21

FIG. 7A

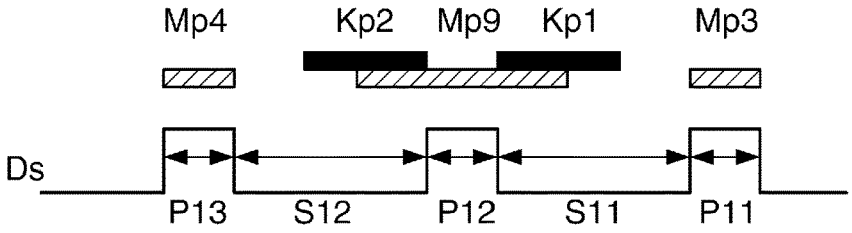

FIG. 7B

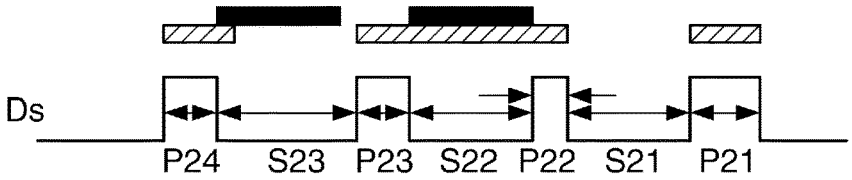

FIG. 7C

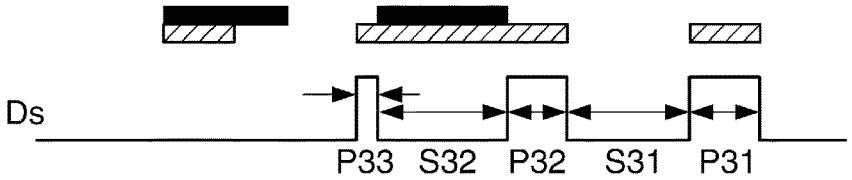

FIG. 7D

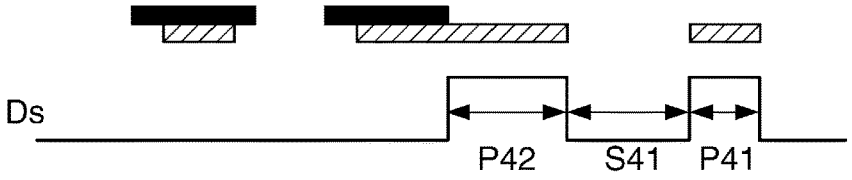

FIG. 7E

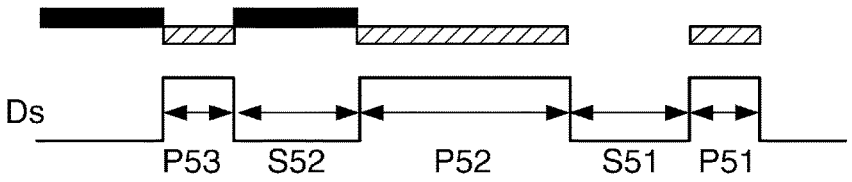

FIG. 8

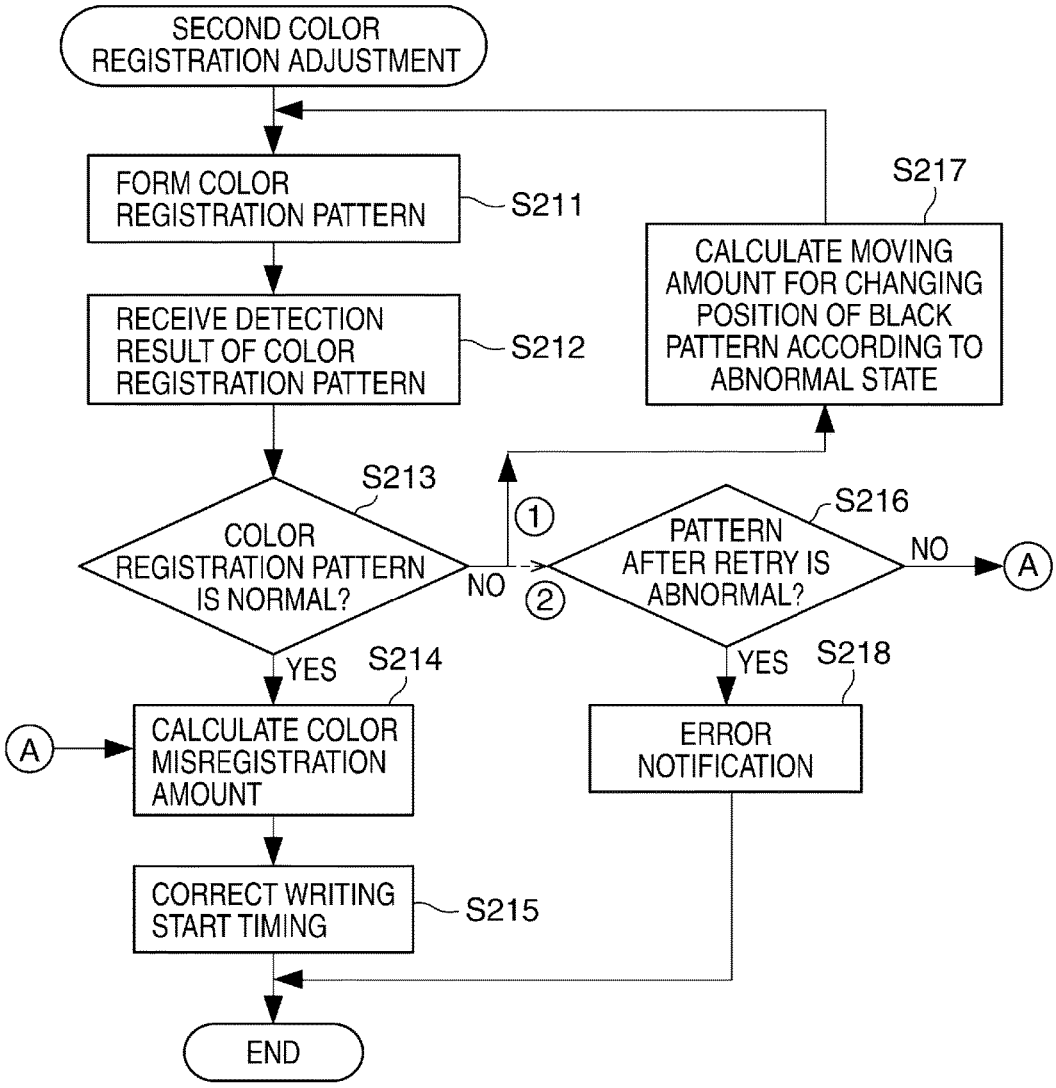
SECOND COLOR REGISTRATION ADJUSTMENT
FORM COLOR REGISTRATION PATTERN
S211
RECEIVE DETECTION RESULT OF COLOR REGISTRATION PATTERN
S212
S213
COLOR REGISTRATION PATTERN IS NORMAL?
NO
YES
S214
CALCULATE COLOR MISREGISTRATION AMOUNT
CORRECT WRITING START TIMING
S215
END
A
1
2
S216
PATTERN AFTER RETRY IS ABNORMAL?
NO
YES
S217
CALCULATE MOVING AMOUNT FOR CHANGING POSITION OF BLACK PATTERN ACCORDING TO ABNORMAL STATE
S218
ERROR NOTIFICATION

FIG. 9

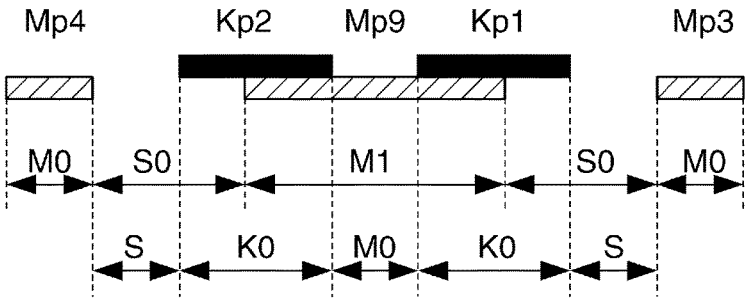
Mp4
Kp2
Mp9
Kp1
Mp3
M0
S0
M1
S0
M0
S
K0
M0
K0
S

FIG. 10A

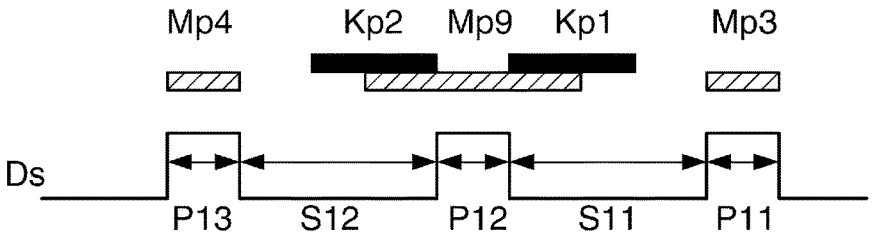

FIG. 10B

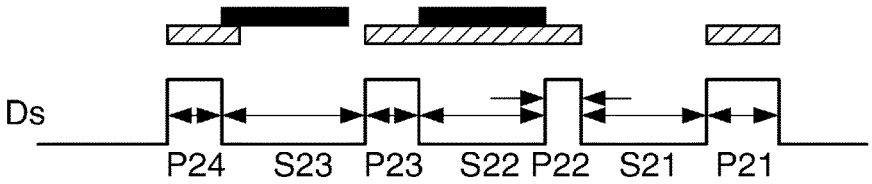

FIG. 10C

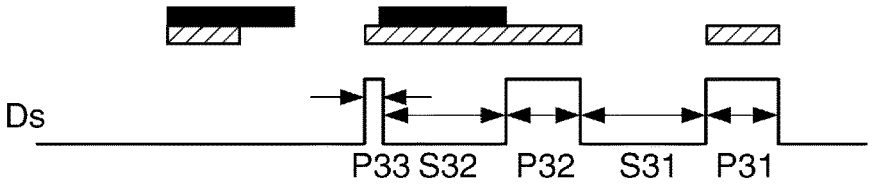

FIG. 10D

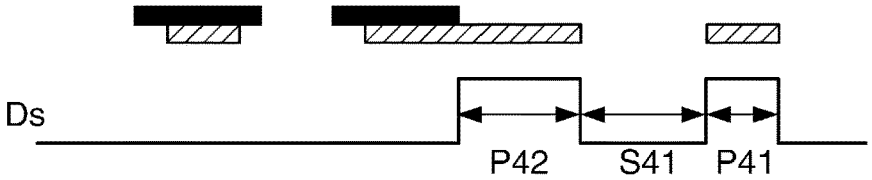

FIG. 10E

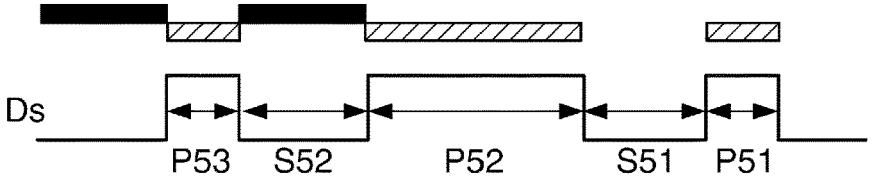

FIG. 10F

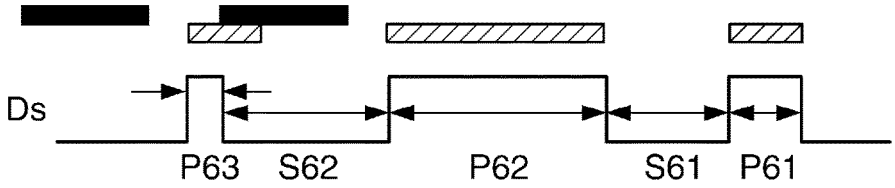

FIG. 10G

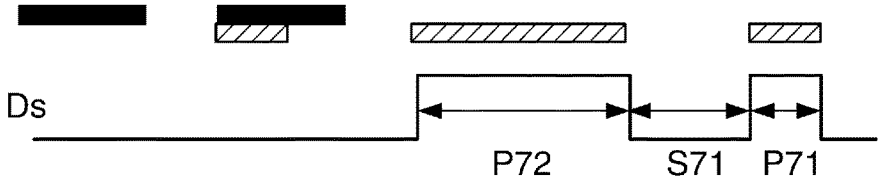

FIG. 10H

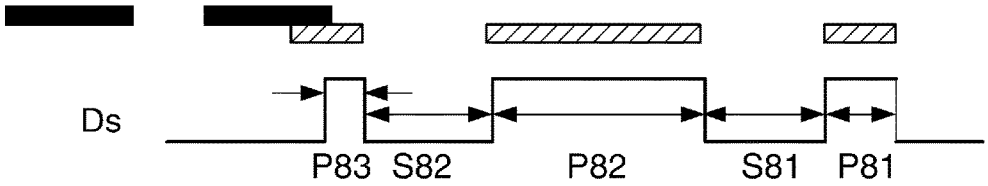

FIG. 10I

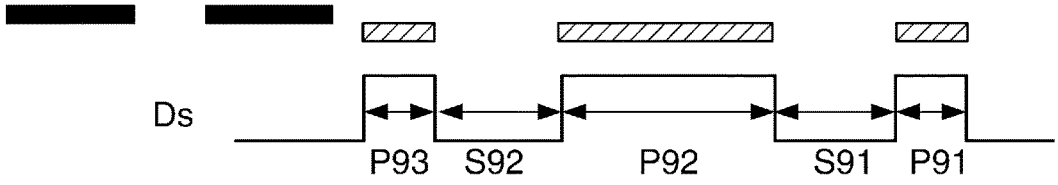

FIG. 11

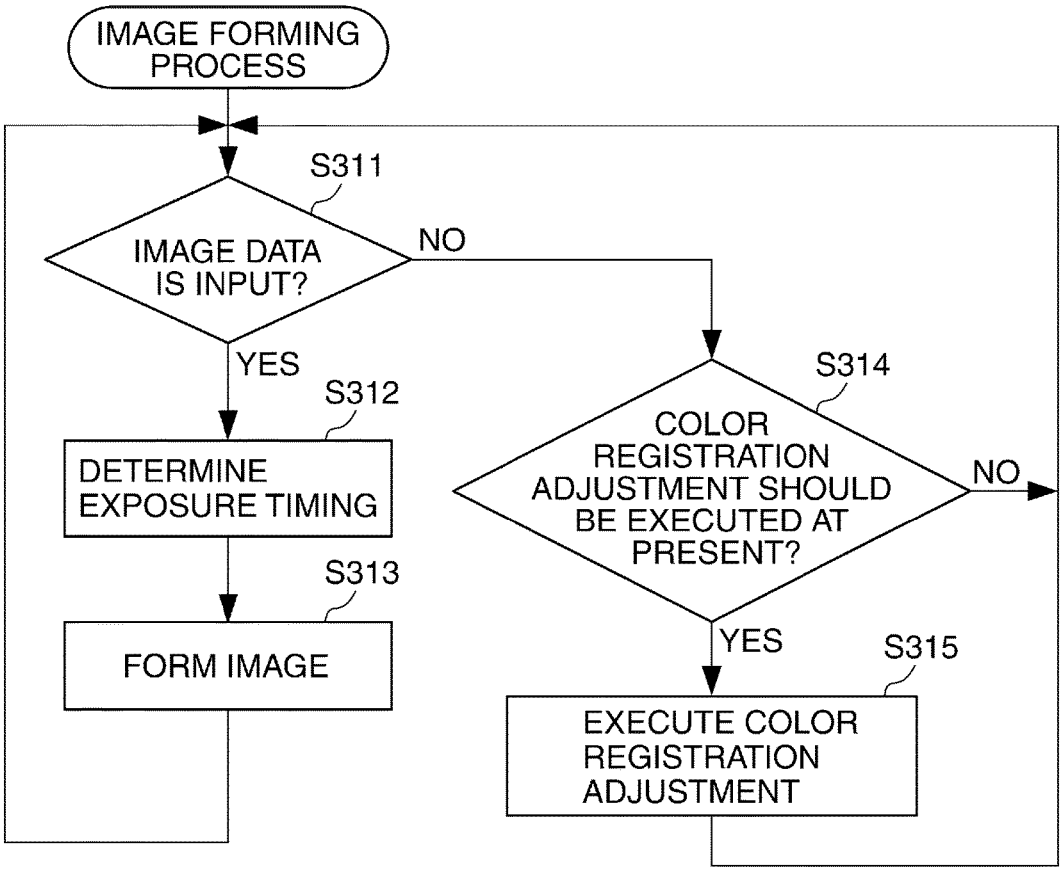
IMAGE FORMING PROCESS
S311
IMAGE DATA IS INPUT?
NO
YES
S312
DETERMINE EXPOSURE TIMING
S313
FORM IMAGE
S314
COLOR REGISTRATION ADJUSTMENT SHOULD BE EXECUTED AT PRESENT?
NO
YES
S315
EXECUTE COLOR REGISTRATION ADJUSTMENT

IMAGE FORMING APPARATUS CAPABLE OF CORRECTING POSITION OF IMAGE FORMED ON IMAGE BEARING MEMBER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a position correction control that corrects a position of an image formed on an image bearing member in an image forming apparatus.

Description of the Related Art

An image forming apparatus of an electrophotographic system has image forming units that form images using toners for respective color components. The images formed with these image forming units are transferred onto an image bearing member so as to superimpose. As a result of this, a multicolor image is generated. The image forming apparatus transfers the multicolor image on the image bearing member to a sheet, fixes the multicolor image to the sheet with heat and pressure by a fixing device, and outputs the printed sheet.

Since such an image forming apparatus superimposes images formed with a plurality of image forming units, when at least one image forming unit forms an image at a position different from a target position, color misregistration occurs in a multicolor image on a printed sheet, which lowers quality of the multicolor image.

Accordingly, an image forming apparatus makes an image forming unit form a measurement image with a toner in a predetermined color, measures the measurement image with a sensor, and adjusts an image forming position of the image forming unit on the basis of a measurement result of the sensor. As a result of this, the color misregistration of the multicolor image is reduced.

The sensor that measures the measurement image is provided with a light emitting element and light receiving element, for example. The light emitting element irradiates the image bearing member, and the light receiving element receives reflected light from the image bearing member and reflected light from the measurement image. An output value of the sensor varies according to intensity of the reflected light from the measurement image received with the light receiving element. The image forming apparatus determines positional relationship of the measurement image on the basis of the output value of the sensor, and corrects relative misregistration of the image forming position on the basis of the positional relationship concerned. However, when difference between a reflectance of the image bearing member and a reflectance of the toner of the predetermined color is minute, the positional relationship of the measurement image may not be determined. That is, when the difference between the intensity of the reflected light from the measurement image and the intensity of the reflected light from the image bearing member is minute, the image forming apparatus may not distinguish the reflected light from the measurement image and the reflected light from the image bearing member.

The technique disclosed in Japanese Laid-Open Patent Publication (Kokai) No. 2012-3234 (JP 2012-3234A) measures a position of a measurement image formed with a toner of a predetermined color using a superimposed measurement image. The superimposed measurement image is formed by superimposing a measurement image that is formed using the toner of the predetermined color on a measurement image formed using a toner of another color different from the predetermined color. It should be noted that the reflectance of the toner of the other color differs from the reflectance of the image bearing member. In the superimposed measurement image of the above-mentioned publication, the measurement image of the predetermined color has a slit and the measurement image of the other color appears in the slit. The above-mentioned sensor outputs the output value corresponding to the intensity of the reflected light from the measurement image of the other color appeared in the slit. Since the output value of the sensor also varies when the positional relationship between the measurement image of the predetermined color and the measurement image of the other color varies, the image forming apparatus is able to measure the position of the measurement image in the predetermined color.

However, when the misregistration of the measurement image of the predetermined color goes beyond a tolerance, the measurement image of the predetermined color may be superimposed on another measurement image different from the superimposed measurement image. Accordingly, when the misregistration of the measurement image of the predetermined color goes beyond the tolerance, the image forming position of the measurement image of the predetermined color is misdetected. Accordingly, when the misregistration of the measurement image of the predetermined color goes beyond the tolerance, the image forming apparatus cannot correct the color misregistration appropriately.

SUMMARY OF THE INVENTION

The present invention provides an image forming apparatus that is capable of determining whether a measurement image is formed normally.

Accordingly, a first aspect of the present invention provides an image forming apparatus including an image bearing member, a first image forming unit configured to form a first image on the image bearing member using a first color toner of which reflectance is higher than the image bearing member, a second image forming unit configured to form a second image on the image bearing member using a second color toner of which reflectance is lower than the first color, a controller configured to control the first image forming unit to form a first measurement image on the image bearing member, and to control the second image forming unit to form a second measurement image such that the second measurement image is superimposed on the first measurement image formed on the image bearing member, an irradiation unit configured to irradiate the image bearing member with light, an output unit configured to have a light receiving section that receives reflected light from the first measurement image and the second measurement image, and to output a signal based on a result of the reflected light received by the light receiving section, the signal including a first signal and a second signal, a detection unit configured to detect color misregistration based on a timing at which the output unit outputs the first signal, a correction unit configured to correct a positional relationship between the first image and the second image based on a detection result of the detection unit, and a prohibition unit configured to prohibit the correction unit from correcting the positional relationship based on the detection result in a case where a period during which the output unit outputs the first signal is different from a predetermined period.

According to the present invention, it is capable of determining whether the measurement image is formed normally, which enables to correct color misregistration appropriately.

Further features of the present invention will become apparent from the following description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view schematically showing a configuration of an image forming apparatus according to a first embodiment of the present invention.

FIG. **2** is a block diagram schematically showing a control system of the image forming apparatus shown in FIG. **1**.

FIG. **3** is a flowchart showing procedures of a color registration adjustment using the image forming apparatus shown in FIG. **1**.

FIG. **4** is a view showing a color registration pattern.

FIG. **5** is a view schematically showing a configuration of a pattern detection sensor.

FIG. **6**A is a view showing a composite pattern as a color registration pattern and a waveform of a detection signal in a normal state. FIG. **6**B is a view showing a composite pattern as a color registration pattern and a waveform of a detection signal in an abnormal state.

FIG. **7**A is a view showing a section of the composite pattern in the normal state and a corresponding detection signal. FIG. **7**B through FIG. **7**E are views showing sections of the composite patterns in the abnormal state and corresponding detection signals, respectively.

FIG. **8** is a flowchart showing procedures of a second color registration adjustment executed by an image forming apparatus according to a second embodiment of the present invention.

FIG. **9** is a view showing a section of a composite pattern in a color registration pattern in a normal state.

FIG. **10**A through FIG. **10**I are views showing sections of composite patterns.

FIG. **11** is a flowchart showing an image forming operation that the image forming apparatus in FIG. **1** corrects an image writing start timing on the basis of a correction amount and forms an image according to image data.

DESCRIPTION OF THE EMBODIMENTS

Hereafter, embodiments according to the present invention will be described in detail with reference to the drawings.

FIG. **1** is a sectional view schematically showing a configuration of an image forming apparatus **100** according to a first embodiment of the present invention. The image forming apparatus **100** forms a color image by superimposing a plurality of images.

The image forming apparatus **100** is provided with image forming units **101***a*, **101***b*, **101***c*, and **101***d*. The image forming units **101***a*, **101***b*, **101***c*, and **101***d* respectively form a yellow (Y) image, magenta (M) image, cyan (C) image, and black (K) image. The image forming units **101***a*, **101***b*, **101***c*, and **101***d* are respectively provided with photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*. A photosensitive layer is formed on a surface of each of the photosensitive drums **1***a*, **1***b* **1***c*, and **1***d*. The photosensitive layer of each of the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* functions as a photoreceptor. The photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* are respectively rotated by motors (not shown). Electrostatic chargers (electrification unit) **12***a*, **12***b*, **12***c*, and **12***d*, exposure devices (exposure unit) **15***a*, **15***b*, **15***c*, and **15***d*, and development devices (developing unit) **16***a*, **16***b*, **16***c*, and **16***d* are arranged around the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*. Moreover, transfer rollers **17***a*, **17***b*, **17***c*, and **17***d* are respectively arranged around the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*.

A high voltage power supply (not shown) applies voltage to the electrostatic chargers **12***a*, **12***b*, **12***c*, and **12***d*. The electrostatic chargers uniformly charge the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* on the basis of the voltage supplied from the high voltage power supply.

Each of the exposure devices **15***a*, **15***b*, **15***c*, and **15***d* is provided with a light source that projects a laser beam, a controlling driver that controls the laser beam, a polygon mirror that deflects the laser beam, and a polygon motor that drivingly rotates the polygon mirror. Moreover, the exposure devices **15***a*, **15***b*, **15***c*, and **15***d* are provided with various mirrors for guiding the laser beams to the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*, respectively. The controlling drivers respectively control the laser beams projected from the light sources on the basis of image data. When the polygon motors rotate, the laser beams respectively scan the photosensitive drum. Accordingly, electrostatic latent images are formed on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* on the basis of the image data.

The development devices **16***a*, **16***b*, **16***c*, and **16***d* respectively develop the electrostatic latent images on the photosensitive drums **1***a*, **1***b*, and **1***c* and **1***d* using toners. Accordingly, toner images are born on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*. The yellow toner image is born on the photosensitive drum **1***a*. The magenta toner image is born on the photosensitive drum **1***b*. The cyan toner image is born on the photosensitive drum **1***c*. The black toner image is born on the photosensitive drum **1***d*.

The transfer rollers **17***a*, **17***b*, **17***c*, and **17***d* transfer the toner images on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* to an intermediate transfer belt **5**. The toner images of the four colors on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* are sequentially transferred so as to be superimposed, and a full color toner image **6** is formed on the intermediate transfer belt **5** that is an intermediate transfer medium. The intermediate transfer belt **5** is looped over a plurality of rollers including a driving roller **2** and roller **3**. The driving roller **2** is rotated by a motor (not shown). When the driving roller **2** rotates, the intermediate transfer belt **5** rotates in a direction of an arrow A. The toner image **6** born on the intermediate transfer belt **5** is conveyed to a transfer nip position between the roller **3** and a transfer roller **4**. An area where the roller **3** and the transfer roller **4** nip the intermediate transfer belt **5** is the transfer nip position. Moreover, a pair of pattern detection sensors **7***a* and **7***b* are arranged so as to face the belt surface of the intermediate transfer belt **5**. The pattern detection sensors **7***a* and **7***b* detect a color registration pattern formed on the intermediate transfer belt **5**. Details of the color registration pattern will be mentioned later.

The image forming apparatus **100** has two sets of conveying roller pairs **10** and a registration roller pair **13**. The conveying roller pairs **10** and the registration roller pair **13** function as a conveyance mechanism that conveys a sheet along a conveyance path **11**. The registration roller pair **13** controls a sheet conveyance timing so that a timing at which the toner image **6** on the intermediate transfer belt **5** reaches the transfer nip position matches a timing at which the sheet reaches the transfer nip position. The toner image **6** on the intermediate transfer belt **5** is transferred to the sheet by applying transfer voltage to the transfer roller **4** while the toner image **6** on the intermediate transfer belt **5** and the sheet are passing through the transfer nip position. A con-

veying belt **12** brings out the sheet to which the toner image **6** was transferred to a fixing device **14**.

The fixing device **14** has a fixing unit having a heater and a pressure unit. The pressure unit presses the toner image **6** to the sheet, while the heater heats the toner image **6**. As a result of this, the toner image **6** on the sheet is fixed to the sheet. The sheet to which the toner image **6** was fixed by the fixing device **14** is ejected from the image forming apparatus **100** by an ejecting roller (not shown).

FIG. **2** is a block diagram schematically showing a control system of the image forming apparatus **100** shown in FIG. **2**.

The control system shown in FIG. **2** is provided with a CPU **109** that controls each part of the image forming apparatus **100**. The CPU **109** is connected with the image forming units **101***a*, **101***b*, **101***c*, and **101***d*, a ROM **110**, a RAM **119**, comparators **301***a* and **301***b*, and the pattern detection sensors **7***a* and **7***b*. Moreover, the comparator **301***a* compares outputs of the pattern detection sensor **7***a* and a threshold setting unit **921***a*, and the comparator **301***b* compares outputs of the pattern detection sensor **7***b* and a threshold setting unit **921***b*.

The CPU **109** controls each component member on the basis of a program stored in the ROM **110**. The CPU **109** makes the image forming units **101***a*, **101***b*, **101***c*, and **101***d* form an image on the basis of image data. Moreover, when correcting color misregistration, the CPU **109** makes the image forming units **101***a*, **101***b*, **101***c*, and **101***d* form color registration patterns on the basis of measurement image data. The ROM **110** stores various programs and the measurement image data. The RAM **119** functions as a work area for the CPU **109**.

The image forming units **101***a*, **101***b*, **101***c*, and **101***d* form images in response to instructions of the CPU **109**. That is, the exposure devices **15***a*, **15***b*, **15***c*, and **15***d* of the image forming units **101***a*, **101***b*, **101***c*, and **101***d* make the laser diodes output the light beams according to image data so that the electrostatic latent images of the corresponding colors are respectively formed on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d*. The development devices **16***a*, **16***b*, **16***c*, and **16***d* develop the electrostatic latent images to form the toner images of the four colors. The toner images are sequentially transferred to the intermediate transfer belt **5** and are superimposed to form a color image.

The pattern detection sensors **7***a* and **7***b* are irregular-reflection optical sensors that receive irregular reflection light from the color registration pattern formed on the intermediate transfer belt **5**. As shown in FIG. **4**, the pattern detection sensor **7***a* is arranged so as to face a color registration pattern **400***a* that is formed near one end in a direction that intersects perpendicularly with the conveyance direction of the intermediate transfer belt **5**, for example. Moreover, as shown in FIG. **4**, the pattern detection sensor **7***b* is arranged so as to face a color registration pattern **400***b* that is formed near the other end in the direction that intersects perpendicularly with the conveyance direction of the intermediate transfer belt **5**, for example.

The pattern detection sensor **7***a* detects the color registration pattern **400***a*, and outputs an analog signal Asa to the comparator **301***a*. Similarly, the pattern detection sensor **7***b* detects the color registration pattern **400***b*, and outputs an analog signal Asb to the comparator **301***b*.

The comparator **301***a* is an analog/digital converter that compares the level of the analog signal Asa with a threshold Tha and outputs a digital signal Dsa as an output signal. Similarly, the comparator **301***b* is an analog/digital converter that compares the level of the analog signal Asb with a threshold Thb and outputs a digital signal Dsb as an output signal. That is, the comparator **301***a* compares the level of the analog signal Asa from the pattern detection sensor **7***a* with the threshold Tha set up by the threshold setting unit **921***a*, and outputs the digital signal Dsa, which is a comparison result of whether the level is equal to or more than the threshold, to the CPU **109**. Similarly, the comparator **301***b* compares the level of the analog signal Asb from the pattern detection sensor **7***b* with the threshold Thb set up by the threshold setting unit **921***b*, and outputs the digital signal Dsb, which is a comparison result of whether the level is equal to or more than the threshold, the CPU **109**.

A the CPU **109** calculates a color misregistration amount by processing these digital signals Dsa and Dsb, and adjusts the writing start timing of each exposure device corresponding to the color misregistration amount. Furthermore, the CPU **109** functions as an adjusting unit that adjusts an image forming position of each color on the basis of the calculated color misregistration amount.

The image forming apparatus **100** executes a color registration adjustment. The pattern detection sensors **7***a* and **7***b* detect the color registration patterns **400***a* and **400***b* formed on the intermediate transfer belt **5**. The CPU **109** obtains relative misregistrations between the image forming positions of the toner images of the four colors (color misregistration amounts) on the basis of the detection results of the patterns **400***a* and **400***b* by the pattern detection sensors **7***a* and **7***b*. Then, the CPU **109** determines correction amounts on the basis of the color misregistration amounts, and adjusts the image forming positions on the basis of the correction amounts concerned. As a result of this, since the images of the four colors are formed so as to be superimposed, the color misregistration is corrected. The image forming positions are corrected by adjusting the image writing start timings of the exposure devices **15***a*, **15***b*, **15***c*, and **15***d*, for example.

Hereinafter, the color registration adjustment will be described.

FIG. **3** is a flowchart showing procedures of the color registration adjustment using the image forming apparatus **100** shown in FIG. **1**. The CPU **109** of the image forming apparatus **100** performs the color registration adjustment according to a color registration adjustment program stored in the ROM **110**. The color registration adjustment includes a pattern-abnormality detection step for detecting an abnormal condition showing that the image forming position of the pattern image of the second color exceeds tolerance.

As shown in FIG. **3**, when the color registration adjustment starts, the CPU **109** first makes the image forming units **101***a*, **101***b*, **101***c*, and **101***d* form the color registration patterns **400***a* and **400***b* on the intermediate transfer belt **5** on the basis of measurement image data (step **S111**). In the step **S111**, the color registration patterns **400***a* and **400***b* are formed on the intermediate transfer belt **5**.

FIG. **4** is a view showing the color registration patterns **400***a* and **400***b*.

The color registration patterns **400***a* and **400***b* are formed at the positions that pass measuring positions of the pattern detection sensors **7***a* and **7***b*. The color registration patterns **400***a* and **400***b* on the intermediate transfer belt **5** are formed with a predetermined distance away from each other in a width direction that intersects perpendicularly with the conveyance direction of the intermediate transfer belt **5**, for example. The pattern detection sensor **7***a* measures the color registration pattern **400***a*, and the pattern detection sensor **7***b* measures the color registration pattern **400***b*.

Each of the color registration patterns **400***a* and **400***b* includes a pattern of a reference color with high reflectance, a pattern of a color with high reflectance other than the reference color, and a composite pattern that combines a pattern of the reference color with high reflectance and a pattern of a color with low reflectance. Furthermore, patterns of one group included in each of the color registration patterns **400***a* and **400***b* incline by a first angle in a predetermined direction with respect to the conveyance direction of the intermediate transfer belt **5**. Patterns of another group incline by a second angle different from the first angle with respect to the conveyance direction of the intermediate transfer belt **5**. Then, the patterns of the one group and the patterns of the other group are formed so as to be symmetrical with respect to the line that intersects perpendicularly with the conveyance direction of the intermediate transfer belt **5**.

Each of the color registration patterns **400***a* and **400***b* has magenta patterns Mp**1**, Mp**2**, Mp**3**, Mp**4**, Mp**5**, Mp**6**, Mp**7**, Mp**8**, Mp**9**, and Mp**10**, cyan patterns Cp**1** and Cp**2**, yellow patterns Yp**1** and Yp**2**, and black patterns Kp**1**, Kp**2**, Kp**3**, and Kp**4**.

The magenta patterns are the reference color patterns with the high reflectance for measuring the color misregistration amount. The width of each of the patterns Mp**9** and Mp**10** is broader than the width of the each of the patterns Mp**1** through Mp**8**. The yellow patterns Yp**1** and Yp**2**, and the cyan patterns Cp**1** and Cp**2** are not the reference color patterns, but they are patterns with the high reflectance. The black patterns are patterns with the low reflectance as compared with the yellow, magenta, and cyan patterns.

The composite patterns are used for detecting the color misregistration of the black patterns with the low reflectance. The composite patterns are formed by superimposing an upper layer that consists of the black patterns Kp**1** and Kp**2** (Kp**3** and Kp**4**) on a base layer that consists of the magenta pattern Mp**9** (Mp**10**) that is the reference color pattern with the high reflectance. When a reflected light from the magenta pattern Mp**9** (Mp**10**) that appears in a slit between the black patterns Kp**1** and Kp**2** (Kp**3** and Kp**4**) is received, the position of the slit (i.e., the positions of the black patterns) is detected. As a result of this, the color misregistration amount of the black pattern to the reference color pattern is detected. As shown in FIG. **4**, dotted lines Dp indicate the measuring positions where the pattern detection sensors **7***a* and **7***b* measure the color registration patterns **400***a* and **400***b*. It should be noted that the slits are prolonged in the directions that intersect the conveyance direction of the intermediate transfer belt **5**. Moreover, the reference color patterns with the high reflectance are formed in front of and behind each of the composite patterns in the conveyance direction of the intermediate transfer belt **5** so as to be adjacent to each of the composite patterns.

Referring back to FIG. **3**, after the color registration patterns were formed on the intermediate transfer belt **5** (step S**111**), the CPU **109** makes the pattern detection sensors **7***a* and **7***b* detect the color registration patterns **400***a* and **400***b*, and the CPU **109** receives detection results (step S**112**).

FIG. **5** is a view schematically showing a configuration of the pattern detection sensor **7***a*. Although FIG. **5** shows the pattern detection sensor **7***a* that detects the color registration pattern **400***a*, the pattern detection sensor **7***b* that detects the color registration pattern **400***b* has the same configuration.

As shown in FIG. **5**, the pattern detection sensor **7***a* is provided with a light emitting section **201** and a light receiving section **202**. The light emitting section **201** is a light emitting element that irradiates the intermediate transfer belt **5** with light according to a driving current. The light emitted from the light emitting section **201** irradiates the intermediate transfer belt **5** or the color registration pattern **400***a* formed thereon. The area on the intermediate transfer belt **5** irradiated with the light of the light emitting section **201** includes the measuring point. While a pattern included in the color registration pattern **400***a* is passing the measuring position, the light receiving section **202** receives irregular reflection light from the pattern. On the other hand, while the color registration pattern **400***a* is not passing the measuring position, the light receiving section **202** receives irregular reflection light from the surface of the intermediate transfer belt **5**. The light receiving section **202** has a light receiving element that outputs the photocurrent corresponding to the light amount of the received light. The light receiving section **202** converts the photocurrent of the light receiving element into an analog detection signal (voltage value) As, and outputs it.

Referring back to FIG. **3**, after receiving the detection results about the color registration patterns from the pattern detection sensors **7***a* and **7***b*, the CPU **109** determines whether the color registration patterns are normal (step S**113**).

FIG. **6**A is a view showing the composite pattern in the color registration pattern and a waveform of a detection signal of the pattern detection sensor **7***a* in a normal state. FIG. **6**B is a view showing a composite pattern in the color registration pattern and a waveform of a detection signal of the pattern detection sensor **7***a* in an abnormal state.

Each of FIG. **6**A and FIG. **6**B shows the composite pattern, the detection signal output from the pattern detection sensor **7***a* at the time when the pattern detection sensor **7***a* detects the composite pattern, and the detection signal (binary) output from the comparator **301***a*.

The width of the magenta pattern Mp**9** is wider than the width of the magenta pattern Mp**3** in the conveyance direction. Similarly, the width of the magenta pattern Mp**9** is wider than the width of the magenta pattern Mp**4** in the conveyance direction. FIG. **6**A shows the normal state in which the magenta pattern with the high reflectance and the black pattern with the low reflectance are located in normal positions. On the other hand, FIG. **6**B shows the abnormal state in which the position of the black pattern cannot be recognized normally because the magenta pattern with the high reflectance and the black pattern with the low reflectance were relatively shifted.

When the composite pattern is in the normal state as shown in FIG. **6**A, a middle point between a centroid position of a detection signal (pulse) at the time of detecting the pattern Mp**4** and a centroid point of a detection signal (pulse) at the time of detecting the pattern Mp**3** agrees with a centroid point of a detection signal (pulse) at the time of detecting the pattern Mp**9**. It should be noted that the magenta pattern Mp**9** appears in the slit between the black patterns Kp**2** and Kp**1**. A period J**11** is equivalent to a period between the centroid point of the detection signal (pulse) at the time of detecting the pattern Mp**3** and the centroid point of the detection signal (pulse) at the time of detecting the pattern Mp**9** that appears between the patterns Kp**2** and Kp**1**. Furthermore, a period J**12** is equivalent to a period between the centroid point of the detection signal (pulse) at the time of detecting the pattern Mp**9** that appears between the patterns Kp**2** and Kp**1** and the centroid point of the detection signal (pulse) at the time of detecting the pattern Mp**4**.

On the other hand, when the composite pattern is in the abnormal state as shown in FIG. **6**B, since the magenta

pattern Mp4 is covered with the black pattern Kp2, the detection signal of the magenta pattern Mp4 does not appear. However, the black pattern Kp1 covers a part of the magenta pattern Mp9. Accordingly, since the both ends (front end and rear end) of the magenta pattern Mp9 in the conveyance direction are exposed, the detection signals corresponding to the both ends of the magenta pattern Mp9 exceed the threshold. Accordingly, three pulses, which include two pulses corresponding to the two detection signals of the magenta pattern Mp9 and one pulse corresponding to the detection signal of the magenta pattern Mp3, are output. In this case, the misregistration amount of the black pattern to the magenta pattern is equivalent to "z" in FIG. 6B.

However, the CPU 109 determines that the pulses of the both sides in FIG. 6B were obtained from the reference color patterns Mp4 and Mp3, and determines that the center pulse was output due to the reflected light from the pattern Mp9 that appears between the patterns Kp2 and Kp1. In this case, the CPU 109 corrects the writing start timing of a black image so that the period J21 becomes equal to the period J22, for example. As a result, the correction for misregistration that is different from the actual misregistration amount "z" will be performed, and an abnormal color image in which the position of the black image is shifted from the positions of the other color images will be output.

In order to avoid the output of such an abnormal image, it is necessary to determine the misregistration amount of the color registration pattern correctly.

Determination of whether the color registration pattern is normal is performed as follows.

FIG. 7A is a schematic view showing a section of the composite pattern in the normal state and a corresponding detection signal. FIG. 7B through FIG. 7E are views showing sections of the composite patterns in the abnormal state and corresponding detection signals, respectively.

In each of FIG. 7A through FIG. 7E, an upper part is a schematic sectional view of the composite pattern, and a lower part shows a detection signal (pulse) of the composite pattern that is detected by the pattern detection sensor. When the pulse width corresponding to the pattern Mp4, the pulse width corresponding to the pattern Mp3, the pulse width corresponding to the pattern Mp3, and the pulse width corresponding to the pattern Mp9 that appears between the patterns Kp2 and Kp1 are outside a predetermined pulse width range, it is determined as the abnormal state. Moreover, when a period between the first pulse corresponding to the pattern Mp3 and the third pulse corresponding to the pattern Mp4 is outside a predetermined period range, the composite pattern is determined as the abnormal state.

The predetermined pulse width range is determined on the basis of a pulse width of an ideal digital signal that is determined according to a physical width of a specific pattern in the composite pattern at the position where the pattern passes the sensor, the conveyance speed of the color registration pattern, and the threshold used when an analog signal is digitized. Moreover, the predetermined period range is determined on the basis of a physical distance between the reference color patterns Mp3 and Mp4, and the conveyance speed of the color registration pattern.

Hereinafter, a concrete abnormality detecting method for the composite pattern performed in the step S113 (FIG. 3) will be described.

In FIG. 7A through FIG. 7E, each of symbols P11 through P53 indicates a pulse width (period) corresponding to a specific pattern. Moreover, each of symbols S11 through S52 indicates a period corresponding to an interval between adjacent pulses. For example, the symbol S11 indicates a period between fall of a first pulse (width P11) and rise of a second pulse (width P12). The symbol S12 indicates a period between fall of the second pulse (width P12) and rise of a third pulse (width P13).

In FIG. 7A, the symbol P11 indicates the width (period) of the pulse that is output after comparing the analog signal obtained from the magenta pattern Mp3 with the threshold. The symbol P12 indicates the width (period) of the pulse obtained from the magenta pattern Mp9 that appears between the black patterns Kp1 and Kp2. Moreover, the symbol P13 indicates the width (period) of the pulse obtained from magenta pattern Mp4. When the composite pattern is in the normal state, the pulse widths P11, P12, and P13 become equal to ideal pulse widths shown in FIG. 7A, and the period (P11+S11+P12+S12) between the output timing of the first pulse (width P11) and the output timing of the third pulse (width P13) becomes equal to a normal value shown in FIG. 7A.

Next, in the example of FIG. 7B, the black pattern Kp2 runs onto the magenta pattern Mp4, the black pattern Kp1 runs onto the magenta pattern Mp9, and four pulses appear. In this case, when the widths (periods) of the right three pulses are measured, the pulse widths P22 and P23 are respectively shorter than the normal pulse widths P12 and P13. The period (P21+S21+P22+S22) between the output timing of the first pulse (width P21) and the output timing of the third pulse (width P23) is shorter than the predetermined period (P11+S11+P12+S12). Accordingly, the composite pattern in FIG. 7B is determined to be in the abnormal state.

Next, in the example of FIG. 7C, the black pattern Kp2 runs onto the magenta pattern Mp4, the black pattern Kp1 runs onto the magenta pattern Mp9, and three pulses appear. In this case, when the widths (periods) of the right three pulses are measured, the pulse widths P32 and P33 are respectively shorter than the normal pulse widths P12 and P13. The period (P31+S31+P32+S32) between the output timing of the first pulse (width P31) and the output timing of the third pulse (width P33) is shorter than the predetermined period (P11+S11+P12+S12). Accordingly, the composite pattern in FIG. 7C is determined to be in the abnormal state.

Next, in the example of FIG. 7D, the black pattern Kp2 runs onto the magenta pattern Mp4, the black pattern Kp1 runs onto the magenta pattern Mp9, and two pulses appear. Accordingly, since the number of pulses is fewer than the predetermined number, it is determined as an abnormal pattern. It should be noted that the pulse width P42 is longer than the normal pulse width P12 in this case.

Next, in the example of FIG. 7E, the black pattern Kp2 is located behind the magenta pattern Mp4 in the conveyance direction, and the black pattern Kp1 is located between the magenta pattern Mp4 and the magenta pattern Mp9. Although the period (P51+S51+P52+S52) between the output timing of the first pulse (width P51) and the output timing of the third pulse (width P53) is normal, the pulse width P52 of the second pulse is longer than the normal pulse width P12. Accordingly, it is determined as an abnormal pattern.

When the abnormality of the color registration pattern is detected, the fact that the color registration pattern is abnormal is reported. Furthermore, a color registration pattern may be formed again, for example.

Referring back to FIG. 3, when the color registration pattern is normal ("YES" in the step S113) as a result of determination of whether the color registration pattern is normal, the CPU 109 calculates a color misregistration amount (correction amount) on the basis of the pattern detection result (step S114). Next, the CPU 109 corrects the

writing start timings of the exposure devices **15***a*, **15***b*, **15***c*, and **15***d* on the basis of the calculated color misregistration amount (correction amount) in step S**115**. That is, the CPU **109** determines new writing start timings of the exposure devices **15***a*, **15***b*, **15***c*, and **15***d*, stores them into the RAM **119**, and finishes the color registration adjustment.

On the other hand, as a result of the determination in the step S**113**, when the color registration pattern is abnormal ("NO" in the step S**113**), the CPU **109***a* notifies a user that the pattern position is abnormal through an operation unit (not shown) in step S**116**, and finishes this process.

According to the process in FIG. **3**, it is determined whether the color registration pattern is normal on the basis of not only the number of the pulses at the time of measuring the color registration pattern but also the widths of the pulses. Moreover, it is determined whether the color registration pattern is normal on the basis of the period between the first pulse and the third pulse. This enables to determine the abnormality of the color registration pattern accurately, and enables to notify a user of the result.

The image forming operation that the image forming apparatus **100** forms an image on a sheet according to image data will be described with reference to FIG. **11**. FIG. **11** is a flowchart showing the image forming operation that the image forming apparatus **100** corrects an image writing start timing on the basis of a correction amount and forms an image according to image data. The CPU **109** executes the image forming operation according to a program stored in the ROM **110**.

The CPU **109** determines first whether image data is input (step S**311**). When the image data is input in the step S**311**, the CPU **109** determines exposure timings on the basis of the write start timings stored in the RAM **119** (step S**312**). Then, the CPU **109** controls the image forming units **101***a*, **101***b*, **101***c*, and **101***d* to form images on the basis of image data (step S**313**). After the image forming apparatus **100** forms an image on a sheet, the CPU **109** proceeds with the process to step S**311**.

On the other hand, as a result of the determination in the step S**311**, when the image data is not input, the CPU **109** determines whether the color registration adjustment should be executed at present (step S**314**). For example, when a user inputs a command to execute the color registration adjustment through an operation unit (not shown), or when a temperature difference between an environmental temperature at the time when the last color registration adjustment was executed and a current temperature is more than a predetermined temperature difference, the CPU **109** determines that the color registration adjustment should be executed at present in the step S**314**. When it is determined that the color registration adjustment should be executed at presents, the CPU **109** executes the color registration adjustment shown in FIG. **3** (step S**315**).

After the color registration adjustment is executed in the step S**315**, when determining that the color registration pattern is abnormal, the CPU **109** stops the image forming operation. When the color misregistration amount of the color registration pattern exceeds the tolerance, the CPU **109** determines that the image forming apparatus cannot correct the color misregistration, and prohibits the execution of the image forming operation until the color misregistration amount of the image forming apparatus **100** is fallen within the tolerance.

Moreover, when the CPU **109** determines that the color registration adjustment should not be executed at present in the step S**314**, the CPU **109** returns the process to the step S**311**.

Moreover, after the color registration adjustment is executed, when determining that the color registration pattern is normal, the CPU **109** returns the process to the step S**311**, and waits until image data is input. As mentioned above, the CPU **109** of the image forming apparatus **100** updates the color misregistration amount (correction amount), whenever the color registration adjustment is performed. It should be noted that the CPU **109** repeats the process from the step S**311** to the step S**314** until the main power supply of the image forming apparatus **100** is turned off, or until the color misregistration amount exceeds the tolerance.

The color registration pattern has a composite pattern. A composite pattern is a superimposed measurement image formed so that a pattern image of a first color and a pattern image of a second color overlap. The pattern image of the first color is formed using the toner of the first color. The pattern image of the second color is formed using the toner of the second color. The toner of the second color is a toner of a predetermined color. The second color (predetermined color) is black, for example. The toner of the first color is a toner of another color different from the predetermined color. The first color is magenta, for example. The reflectance of the toner of the first color is higher than the reflectance of the toner of the second color. The pattern image of the first color included in the composite pattern is sufficient to be read by the pattern detection sensors **7***a* and **7***b* that are used for receiving irregular reflection light.

The reference color pattern is formed using the magenta toner that is identical to the toner of the first color. It should be noted that the reference color pattern may be a yellow pattern or a cyan pattern in place of a magenta pattern as long as a pattern has a high reflectance.

Next, a second embodiment of the present invention will be described. FIG. **8** is a flowchart showing procedures of a second color registration adjustment by an image forming apparatus according to the second embodiment. The configuration of the image forming apparatus in the second embodiment is similar to the configuration of the image forming apparatus in the first embodiment, and its description is omitted.

The CPU **109** of the image forming apparatus **100** performs the second color registration adjustment according to a second color registration adjustment program stored in the ROM **110**. In the second color registration adjustment, when the color registration pattern is determined to be in the abnormal state, a new color registration pattern is formed, and the color misregistration is corrected on the basis of the color registration pattern in the normal state.

As shown in FIG. **8**, when the second color registration adjustment is started, the CPU **109** controls the image forming units **101***a*, **101***b*, **101***c*, and **101***d* so as to form color registration patterns (step S**211**). Namely, when executing the color registration adjustment, the CPU **109** generates image data of the four colors that configure the image of the color registration patterns, and outputs them to the image forming units **101***a*, **101***b*, **101***c*, and **101***d*, respectively. The exposure devices **15***a*, **15***b*, **15***c*, and **15***d* of the image forming units **101***a*, **101***b*, **101***c*, and **101***d* respectively form electrostatic latent images on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* by outputting light beams from the laser diodes corresponding to the image data. The electrostatic latent images are developed by the development devices **16***a*, **16***b*, **16***c*, and **16***d*, and are converted into toner images. The toner images formed on the photosensitive drums **1***a*, **1***b*, **1***c*, and **1***d* are sequentially transferred onto the intermediate transfer belt **5** so as to be superimposed. Accord-

ingly, the color registration patterns each of which consists of multicolor pattern images is formed.

After forming the color registration patterns (step S211), the CPU **109** receives the detection results from the pattern detection sensors **7***a* and **7***b* that detected the color registration patterns **400***a* and **400***b* (step S212). The color registration patterns are conveyed with rotation of the intermediate transfer belt **5**. The color registration patterns are read by the pattern detection sensors **7***a* and **7***b*, when passing positions directly under the pattern detection sensors **7***a* and **7***b*. That is, the light emitting sections **201** of the pattern detection sensors **7***a* and **7***b* irradiate patterns of the four colors of the color registration patterns **400***a* and **400***b* formed on the intermediate transfer belt **5**. Then, the light receiving sections **202** read the color registration patterns by receiving irregular reflection components from the patterns of the four colors, and output signals.

After receiving the detection results about the color registration patterns from the pattern detection sensors **7***a* and **7***b* (step S212), the CPU **109** determines whether the color registration patterns are normal (step S213).

FIG. **9** is a view showing a section of a composite pattern in the color registration pattern in the normal state. FIG. **9** shows design values in a case where black patterns and magenta patterns as the reference color patterns in the composite pattern are formed at ideal positions without color misregistration.

As shown in FIG. **9**, symbols M**0** indicate periods during which reference color patterns Mp**4** and Mp**3** and a pattern Mp**9** that appears between patterns Kp**1** and Kp**2** pass the pattern detection sensor **7***a*. Symbols K**0** indicate periods during which the patterns Kp**1** and Kp**2** pass the pattern detection sensor **7***a*. Moreover, symbols S**0** indicate periods during which a gap between the patterns Mp**3** and Mp**9** and a gap between the patterns Mp**9** and Mp**4** pass the pattern detection sensor **7***a*. Furthermore, symbols S indicate periods during which a gap between the patterns Mp**3** and Kp**1** and a gap between the pattern Kp**2** and Mp**4** pass the pattern detection sensor **7***a*. And a symbol M**1** indicate a period during which the entire width of the pattern Mp**9** passes the pattern detection sensor **7***a*.

Referring back to FIG. **8**, as a result of the determination in the step S213, when the color registration pattern is normal ("YES" in the step S213), the CPU **109** calculates a color misregistration amount on the basis of the detection result of the color registration pattern (step S214). Next, the CPU **109** corrects the writing start timing of each exposure device corresponding to the calculated color misregistration amount, stores it to the RAM **119** (step S215), and finishes this color registration adjustment.

On the other hand, as a result of the determination in the step S213, when determining that the composite pattern is abnormal ("NO" in the step S213), the CPU **109** proceeds with the process to the step S217. That is, the CPU **109** calculates a moving amount for changing the positions of the black patterns in order to return the composite pattern to the normal state (step S217).

Hereinafter, a method for returning the composite pattern to the normal state on the basis of the abnormal state of the composite pattern will be described.

FIG. **10**A through FIG. **10**I are views showing sections of composite patterns in various states. FIG. **10**A is a view showing the composite pattern in the normal state, and FIG. **10**B, through FIG. **10**I are views showing the composite patterns in the abnormal state, respectively.

In each of FIG. **10**A through FIG. **10**I, an upper part is a schematic sectional view of the composite pattern, and a lower part shows a waveform of a digital signal obtained by comparing an analog signal with a threshold.

It is determined whether a composite pattern is normal in the same manner as the first embodiment. Namely, when the pulse width obtained from the pattern Mp**4**, the pulse width obtained from the pattern Mp**3**, or the pulse width obtained from pattern Mp**9** that appears between the patterns Kp**1** and Kp**2** is outside the predetermined pulse width range, it is determined that the composite pattern is abnormal. Moreover, when a period between the first pulse and the third pulse is outside a predetermined period range, it is determined that the composite pattern is abnormal. The predetermined pulse width range is determined on the basis of a physical width of each pattern at the position where each pattern passes the sensor, the conveyance speed of the color registration pattern, and a pulse width of an ideal digital signal that is determined according to the threshold used when an analog signal is digitized. Moreover, the predetermined period range is determined on the basis of a physical distance between the reference color patterns Mp**3** and Mp**4**, and the conveyance speed of the patterns.

In the case of FIG. **10**A, pulse widths P**11**, P**12**, and P**13** agree with the normal pulse width M**0**, and a period between the first pulse (width P**11**) and the third pulse (width P**13**) also falls within the normal range. Accordingly, the image position is corrected in a usual sequence in this case.

In the case of FIG. **10**B, although a width P**21** of a first pulse is equal to the normal pulse width M**0**, pulse widths P**22** and P**23** of second and third pulses are shorter than the normal width M**0**, and a period between the first pulse (width P**21**) and the third pulse (width P**23**) is also shorter than the normal period. Accordingly, it is determined as an abnormal pattern. Moreover, since a width P**24** of a fourth pulse is shorter than the normal pulse width M**0** and the period between the first pulse (width P**21**) and the third pulse (width P**23**) is shorter than the normal period, it is determined that the pattern Kp**1** is positioned on the pattern Mp**9** and that the pattern Kp**2** partially runs onto the pattern Mp**4**. In this case, since a middle point between the patterns Kp**1** and Kp**2** is coincident with a centroid point of the third pulse (width P**23**), the period from the centroid point of the first pulse to the middle point between the pattern Kp**1** and Kp**2** becomes P**21**/2+S**21**+P**22**+S**22**+M**0**/2. Moreover, an ideal period from the centroid point of the first pulse to the middle point between the patterns Kp**1** and Kp**2** is equal to M**0**/2+S+K**0**+M**0**/2. Since P**21**=M**0** and S**21**=S**0**, correction time becomes S**0**+P**22**+S**22**−S−K**0** that is obtained by subtracting (M**0**/2+S+K**0**+M**0**/2) from (M**0**/2+S**0**+P**22**+S**22**+M**0**/2), and the composite pattern will be in a normal state by moving the black patterns by the distance corresponding to the correction time.

In the case of FIG. **10**C, although a width P**31** of a first pulse is equal to the normal pulse width M**0**, pulse widths P**32** and P**33** of second and third pulses are shorter than the normal width M**0**, and a period between the first pulse (width P**31**) and the third pulse (width P**33**) is also different from the normal period. Accordingly, it is determined as an abnormal pattern. Since the period between the first pulse (width P**31**) and the third pulse (width P**33**) is shorter than the normal period, and there is no pulse following the third pulse (width P**33**), it is determined that the pattern Kp**2** covers the pattern Mp**4** and that the pattern Kp**1** runs onto the pattern Mp**9**. In this case, the correction time becomes S**0**+P**32**+S**32**−S−K**0** in the same manner as the case of FIG. **10**B, the black patterns are moved in the conveyance direc-

tion by the distance corresponding to the correction time. As a result of this, the composite pattern will be in the normal state.

In a case of FIG. **10**D, although a width P**41** of a first pulse is equal to the normal pulse width W**0**, a width P**42** of a second pulse is longer than the pulse width M**0** and a third pulse is not detected. Accordingly, it is determined as an abnormal pattern. Since a third pulse is not detected and the width P**42** of the second pulse is shorter than the width M**1** corresponding to the width of the pattern Mp**9**, it is determined that the pattern Kp**2** covers the pattern Mp**4** and that the pattern Kp**1** runs onto the pattern Mp**9**. In this case, an period from the centroid point of the first pulse (width P**41**) to the middle point between the patterns Kp**1** and Kp**2** becomes P**41**/2+S**41**+P**42**+K**0**+M**0**/2. Since the ideal period from the centroid point of the first pulse to the middle point between the patterns Kp**1** and Kp**2** is M**0**/2+S+K**0**+M**0**/2 and P**41**=M**0**, the correction time becomes S**41**+P**42**-S that is obtained by subtracting (M**0**/2+S+K**0**+M**0**/2) from (M**0**/2+S**41**+P**42**+K**0**+M**0**/2). The black patterns are moved by the distance corresponding to the correction time. As a result of this, the composite pattern will be in the normal state.

In a case of FIG. **10**E, since a width P**52** of a second pulse is longer than the normal pulse width M**0**, it is determined as the abnormal pattern. However, in this case, it cannot be determined whether the black patterns Kp**1** and Kp**2** sandwich the pattern Mp**4** as shown in FIG. **10**E, sandwich the pattern Mp**3**, or are significantly shifted as shown in FIG. **10**I. Accordingly, the positions of the black patterns are moved by a distance corresponding to M**1**/2+S**0**+M**0**/2 first, and the color registration adjustment sequence is performed again. As a result, when the composite pattern is in the state in FIG. **10**A, the image positions are corrected normally, and the color registration adjustment sequence is finished.

As a result of shifting the positions of the black patterns and performing the color registration adjustment sequence again, when the composite pattern becomes the state of FIG. **10**B, FIG. **10**C, FIG. **10**D, FIG. **10**F, FIG. **10**G, or FIG. **10**H, the black patterns are moved corresponding to each state, and the color registration adjustment sequence is performed again. When the positions of the black patterns are not sure like the case of FIG. **10**E or FIG. **10**I, the black patterns are moved by a distance corresponding to −(M**1**/2+S**0**+M**0**/2) in the direction that is reverse to the above-mentioned case. Then, the color registration adjustment sequence is performed again. As a result, when the composite pattern is in the state in FIG. **10**A, the image positions are corrected normally, and the color registration adjustment sequence is finished. Moreover, when the composite pattern becomes the state of FIG. **10**B, FIG. **10**C, FIG. **10**D, FIG. **10**F, FIG. **10**G, or FIG. **10**H, the black patterns are moved corresponding to each state, and the color registration adjustment sequence is performed again. When the positions of the black patterns are not sure like the case of FIG. **10**E or FIG. **10**I, a user is notified of an error.

In a case of FIG. **10**F, since a width P**63** of a third pulse is shorter than the normal pulse width W**0** and a width P**62** of a second pulse is longer than the normal pulse width M**0**, it is determined as an abnormal pattern. The pulse width P**62** agrees with the width M**1** corresponding the width of the pattern Mp**9**, a period from the centroid point of a first pulse (width P**61**) to the centroid point of the third pulse (width P**63**) is longer than that in the normal state. Accordingly, it is determined that the pattern Kp**2** is positioned in a delay direction than the pattern Mp**4** and that the pattern Kp**1** runs onto the pattern Mp**4**. In this case, an period from the centroid point of the first pulse (width P**61**) to the middle point between the patterns Kp**1** and Kp**2** becomes P**61**/2+S**61**+P**62**+M**0**/2. The ideal period from the centroid point of the first pulse (width P**61**) to the middle point between the patterns Kp**1** and Kp**2** is equal to M**0**/2+S+K**0**+M**0**/2. Since P**61**=M**0**, a correction time becomes S**61**+P**62**+S**62**−S−K**0** that is obtained by subtracting (M**0**/2+S+K**0**+M**0**/2) from (M**0**/2+S**61**+P**62**+S**62**+M**0**/2). Accordingly, the black patterns are moved by the distance corresponding to the correction time. As a result of this, the composite pattern will be in the normal state.

In a case of FIG. **10**G, since a width P**72** of a second pulse agrees with the normal pulse width M**1** and a third pulse is not detected, it is determined that the pattern Kp**1** covers the pattern Mp**4** and that the pattern Kp**2** is positioned in the delay direction than the pattern Mp**4**. In this case, although the middle point between the patterns Kp**1** and Kp**2** is not determined correctly, the period from a centroid point of a first pulse (width P**71**) to the middle point falls within a range between P**71**/2+S**71**+P**72**+S**0**+M**0**+M**0**/2 and P**71**/2+S**71**+P**72**+S**0**+K**0**+M**0**/2. Accordingly, it is assumed that the middle point between the patterns Kp**1** and Kp**2** is positioned at the center of the range (i.e., the period from the centroid point of the first pulse to the middle point is equal to P**71**/2+S**71**+P**72**+S**0**+K**0**/2+M**0**). The ideal period from the centroid point of the first pulse (width P**71**) to the middle point between the patterns Kp**1** and Kp**2** is equal to M**0**/2+S+K**0**+M**0**/2. Since P**71**=M**0**, S**71**=S**0**, and P**72**=M**1**, a correction time becomes 2S**0**+M**1**+M**0**/2−S−K**0**/2 that is obtained by subtracting (M**0**/2+S+K**0**+M**0**/2) from (M**0**/2+S**0**+M**1**+S**0**+K**0**/2+M**0**), and the black patterns are moved by the distance corresponding to the above-mentioned correction time. As a result of this, the composite pattern will be in the normal state.

In a case of FIG. **10**H, since a width P**83** of a third pulse is shorter than the normal pulse width M**0** and a width P**82** of a second pulse agrees with the width M**1** corresponding to the width of the pattern Mp**9**, it is determined as an abnormal pattern. Moreover, since the period from a first pulse (width P**81**) to the third pulse (width P**83**) is shorter than that in the normal state, it is determined that the pattern Kp**2** is positioned in the delay direction than the pattern Mp**4** and that the pattern Kp**1** runs onto the rear edge of the pattern Mp**4**. Accordingly, a period from the centroid point of the first pulse (width P**81**) to the middle point between the patterns Kp**1** and Kp**2** becomes P**81**/2+S**81**+P**82**+S**82**+P**83**+K**0**+M**0**/2. The ideal period from the centroid point of the first pulse (width P**81**) to the middle point between the patterns Kp**1** and Kp**2** is equal to M**0**/2+S+K**0**+M**0**/2. Since P**81**=M**0**, S**81**=S**0**, P**82**=m**1**, and S**82**=S**0**, a correction time becomes 2S**0**+M**1**+P**83**−S that is obtained by subtracting (M**0**/2+S+K**0**+M**0**/2) from (M**0**/2+S**0**+M**1**+S**0**+P**83**+K**0**+M**0**/2), and the black patterns are moved by the distance corresponding the above-mentioned correction time. As a result of this, the composite pattern will be in the normal state.

In a case of FIG. **10**I, the middle point between the pattern Kp**1** and Kp**2** is detected by the same sequence as the case of FIG. **10**E, and the black patterns are moved.

As mentioned above, when the abnormal state of the image positions of the black patterns is detected and the black patterns are returned to the normal positions, the process returns to the normal color registration adjustment sequence.

Referring back to FIG. **8**, after finding the moving amount (writing-start-timing correction amount) of the black patterns for making the composite pattern into the normal state, the CPU **109** forms the color registration pattern again while

correcting the writing start timing of the black patterns (step S211). Next, the CPU **109** receives the pattern detection signal (step S212), and determines whether the color registration pattern is normal (step S213).

As a result of the determination in the step S213, when the color registration pattern is normal ("YES" in the step S213), the CPU **109** calculates the color misregistration amount on the basis of the detection result of the color registration pattern (step S214) as mentioned above. Next, the CPU **109** corrects the writing start timing of each exposure device corresponding to the calculated color misregistration amount (step S215), and finishes this process.

On the other hand, as a result of the determination in the step S213, when the composite pattern is determined as abnormal ("NO" in the step S213), the CPU **109** determines again whether the composite pattern is abnormal even after a retry (step S216). As a result of the determination in the step S216, when determining that the abnormality is cancelled and the composite pattern is normal ("NO" in the step S213), the CPU **109** proceeds with the process to the step S214.

Moreover, as a result of the determination in the step S216, when the composite pattern is abnormal even after the retry ("YES" in the step S216), the CPU **109** notifies a user of an error through the operation unit (not shown) in step S218. Then, the CPU **109** finishes this process after the error notification.

According to the process in FIG. **8**, the abnormality of the composite pattern in the color registration pattern is detected on the basis of not only the number of the pulses based on the pattern but also the period that is the width of each pulse and the period that is the interval between the specific pulses. This allows detecting the abnormality of the composite pattern correctly.

Moreover, according to the second embodiment, the moving amount of the black patterns for returning the composite pattern to the normal state is found corresponding to the abnormal state of the composite pattern (step S217), and the color registration pattern is reformed using the found moving amount (step S211). As a result of this, since the color misregistration is properly corrected using the reformed color registration pattern in the normal state, a normal image is output while avoiding outputting an abnormal image.

Other Embodiments

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

This application claims the benefit of Japanese Patent Application No. 2015-211849, filed Oct. 28, 2015, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. An image forming apparatus comprising:

an image bearing member;

a first image forming unit configured to form a first image on the image bearing member using a first color toner where reflectance is higher than the image bearing member;

a second image forming unit configured to form a second image on the image bearing member using a second color toner where reflectance is lower than the first color toner;

an irradiation unit configured to irradiate the image bearing member with light;

an output unit including a light receiving section that receives reflected light from the image bearing member, and configured to output a signal based on a light receiving result of the light receiving section; and

a processor configured to implement instructions stored in a memory and execute a plurality of tasks, including:

a formation task that controls the first image forming unit and the second image forming unit to form a plurality of measurement images on the image bearing member, wherein the plurality of measurement images include:

a first measurement image formed by the first image forming unit;

a second measurement image formed by the first image forming unit;

a third measurement image formed by the first image forming unit; and

a superimposing measurement image formed by the second image forming unit, superimposed on the second measurement image, wherein the second measurement image is formed between the first measurement image and the third measurement image;

an obtaining task that controls the irradiation unit and the output unit to obtain the signal, which includes a plurality of pulse signals, corresponding to a light receiving result of the reflected lights from the plurality of measurement images received by the light receiving section;

a determining task that determines whether a predetermined condition regarding a period from a first pulse signal, among the plurality of pulse signals, to a third pulse signal, among the plurality of pulse signals, is satisfied;

a detection task that detects color misregistration based on the signal obtained by the obtaining task; and

a control task that controls based on the color misregistration detected by the detection task, an image forming position of the second image to be formed by the second image forming unit,

wherein the processor does not execute the control task in a case where the predetermined condition is not satisfied.

2. The image forming apparatus according to claim **1**, wherein the superimposing measurement image includes a slit that is prolonged in a direction that intersects a conveyance direction of the image bearing member so that the second measurement image appears in the slit.

3. The image forming apparatus according to claim **1**, wherein the processor prohibits the detection task from detecting the color misregistration in a case where the predetermined condition is not satisfied.

4. The image forming apparatus according to claim **1**, wherein the first color toner is magenta and the second color toner is black.

5. The image forming apparatus of the claim **1**, wherein the light receiving section of the output unit receives irregular reflection light.

6. The image forming apparatus according to claim **1**, wherein the processor skips the detection task in a case where the predetermined condition is not satisfied.

7. The image forming apparatus according to claim **1**, wherein:

the superimposing measurement image includes a first superimposing measurement image and a second superimposing measurement image,

the first superimposing measurement image and the second superimposing measurement image are separated by a predetermined distance in a conveyance direction of the image bearing member, and

the second measurement image appears between the first superimposing measurement image and the second superimposing measurement image.

8. The image forming apparatus according to claim **1**, wherein the predetermined condition is satisfied in a case where the period is within a predetermined period.

9. An image forming apparatus comprising:

an image bearing member;

a first image forming unit configured to form a first image on the image bearing member using a first color toner where reflectance is higher than the image bearing member;

a second image forming unit configured to form a second image on the image bearing member using a second color toner where reflectance is lower than the first color toner;

an irradiation unit configured to irradiate the image bearing member with light;

an output unit including a light receiving section that receives reflected light from the image bearing member, and configured to output a signal based on a light receiving result of the light receiving section; and

a processor configured to implement instructions stored in a memory and execute a plurality of tasks, including:

a formation task that controls the first image forming unit and the second image forming unit to form a plurality of measurement images on the image bearing member, wherein the plurality of measurement images include:

a first measurement image formed by the first image forming unit;

a second measurement image formed by the first image forming unit;

a third measurement image formed by the first image forming unit; and

a superimposing measurement image formed by the second image forming unit superimposed on the second measurement image, wherein the second measurement image is formed between the first measurement image and the third measurement image;

an obtaining task that controls the irradiation unit and the output unit to obtain the signal, which includes a plurality of pulse signals, corresponding to light receiving result of the reflected lights from the plurality of measurement images received by the light receiving section;

a determining task that determines a detection error caused by a shift of an image forming position of the superimposing measurement image based on a period from a first pulse signal, among the plurality of pulse signals, to a third pulse signal, among the plurality of pulse signals;

a detection task that detects color misregistration based on the signal obtained by the obtaining task;

a control task that controls, based on the color misregistration detected by the detection task, an image forming position of the second image to be formed by the second image forming unit,

wherein the processor does not execute the control task in a case where the detection error is determined by the determining task.

10. The image forming apparatus according to claim **9**, wherein the superimposing measurement image includes a slit that is prolonged in a direction that intersects a conveyance direction of the image bearing member so that the second measurement image appears in the slit.

11. The image forming apparatus according to claim **9**, wherein the processor prohibits the detection task from detecting the color misregistration in a case where the detection error is determined by the determining task.

12. The image forming apparatus according to claim **9**, wherein the first color toner is magenta and the second color toner is black.

13. The image forming apparatus of the claim **9**, wherein the light receiving section of the output unit receives irregular reflection light.

14. The image forming apparatus according to claim **9**, wherein the processor skips the detection task in a case where the detection error is determined by the determining task.

15. The image forming apparatus according to claim **9**, wherein:

the superimposing measurement image includes a first superimposing measurement image and a second superimposing measurement image,

the first superimposing measurement image and the second superimposing measurement image are separated by a predetermined distance in a conveyance direction of the image bearing member, and

the second measurement image appears between the first superimposing measurement image and the second superimposing measurement image.

16. The image forming apparatus according to claim **9**, wherein the determining task determines the detection error in a case where the period is outside a predetermined period.

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